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MANAGING MOUNTAIN HARDWOODS—

A TEN-YEAR APPRAISAL

BY

GEORGE R. TRIMBLE, JR.

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GEORGE R. TRIMBLE, JR.

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TEN years ago--in 1949--four 5-acre plots were established on the Fernow Experimental Forest near Parsons, West Virginia, to show the effects upon mountain hardwoods of each of four management treatments. This research is similar to other studies now being made on several experimental forests in the Northeast to compare the biological and economical results of different methods of managing forests. Areas large enough to permit the simulation of commercial logging operations are treated by varying intensities of forest management, by different logging cuts and product objectives, and so forth. Later, similar treatments are applied in larger scale studies to compartments ranging in size from 30 to 180 acres.

The first cuts were made on the four Fernow plots in 1949.[1] In 1956, an additional 5-acre plot was selected near the others to serve as a check or comparison with the original undisturbed forest.

This report describes the Fernow stands both before and after treatment, as well as the treatments themselves. It summarizes the effects of treatments, 10 years after the first applications were made, upon volume, cull, timber quality, growth, stand structure, and reproduction.

CONDITION OF THE STAND BEFORE TREATMENT

Originally the stands were composed mainly of three classes of trees: (1) second-growth Appalachian hardwoods, 40 to 45 years of age; (2) old residual trees left from cutting that took place between 1905 and 1910; and (3) a scattering of pole-sized trees that came up in openings created by the death of the American chestnut trees around 1930. Thus prior to cutting, the stands were essentially uneven-aged.

[1] A first report of cutting in these stands was published by the Northeastern Station in 1954 under the title 'Cutting Mountain Hardwood Stands' (3).

Many of the old residuals were culls, and even some of the merchantable trees in this group were partly defective because of rot and poor form.

All of these plots have a site index[2] of 80 for oaks (5, 6, 7). This is a very good site, at least 10 site-index points higher than the average forest site in West Virginia. The soil is a deep (more than 3½ feet) Belmont silt loam derived from limestone.

THE MANAGEMENT PROGRAMS

The experimental treatments applied on the plots can be summed up as follows:

PLOT A

Commercial clear-cut

All merchantable trees down through 6 inches d.b.h. are removed; cull trees are left; and no cultural practices are applied.

PLOT B

Diameter-limit cut

All trees above 15.5 inches d.b.h. are removed. If merchantable, they are harvested; if cull, they are girdled or felled and left. No cultural work or harvest cutting is made in the stand below 15.5 inches. The stand will be cut on a 20-year cutting cycle.

PLOT C

Extensive-selection cut

In this practice trees are marked either for harvest cutting or to be deadened as culls in sizes above 11 inches d.b.h. In addition to deadening culls in the sawtimber stand, another cultural measure is applied: grapevines that are damaging potential crop trees are cut. This plot will be cut on a 10-year cycle. After-logging care on skidroads is a standard practice.

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[2]Average total height of dominant and codominant trees at a base age of 50 years.

PLOT D

Intensive-selection cut

This is a light selection type of cutting with a 5-year cutting cycle. The stand is marked down through the 6-inch diameter class. Marked *trees* are harvested, or deadened if they are culls. Cultural measures may include thinning and pruning as well as deadening culls and cutting grapevines. After-logging care of skidroads is a standard practice.

PLOT E

Check

This is a check plot left untreated for a comparison between treated plots and undisturbed forest conditions.

APPLICATION OF TREATMENTS

Four plots were established side-by-side for cutting treatments in 1949; in 1956 a plot was set up nearby as a check. Prior to treatment, all plots were inventoried 100 percent, sawtimber quality was estimated, and reproduction surveys made. Table 1 gives the pertinent characteristics of the stands before treatment, volumes removed during the following 10 years, and characteristics of the residual stands.

The first application of treatments completed all work prescribed for a long period of time on the clear-cut and diameter-limit plots. On the two selection-system plots, the first treatment concentrated upon conditioning the stand; for example, harvesting holdover and defective trees, eliminating culls, and cutting grapevines. On plot C, grapevines were removed in 1954 as well as during the first and second cuts.

At the end of 5 years, remeasurements were made on all plots. However, the scheduled cutting was not made on the intensive-selection plot with the 5-year cutting cycle (plot D), since of necessity the first or conditioning cut had been so heavy (6,793 board-feet per acre including culls) in order to eliminate the defective and poor growing-stock trees. Thus, the stand was still seriously understocked 5 years later and the scheduled cut was postponed for another 5 years.

Table 1.--Original volume, volume removed, and residual volumes per acre[1]

Management program	Original volume 1949						Volume removed[2]						Residual volume 1959					
	Merchantable			Cull			Merchantable			Cull			Merchantable			Cull		
	M Bd.ft.	100 Cu.ft.	BA	M Bd.ft.	100 Cu.ft.	BA	M Bd.ft.	100 Cu.ft.	BA	M Bd.ft.	100 Cu.ft.	BA	M Bd.ft.	100 Cu.ft.	BA	M Bd.ft.	100 Cu.ft.	BA
Clear-cut	10.8	23.6	95.1	1.2	2.1	7.9	10.8	22.5	89.2	0	0	0	0.9	6.5	31.5	0.6	1.1	4.1
Diameter-limit	11.9	24.2	94.5	.3	.9	3.7	8.5	15.3	55.6	0.2	0.4	1.2	7.9	17.5	73.4	0	.2	.9
Extensive-selection	13.3	24.7	95.6	1.3	2.1	7.4	8.5	14.6	54.7	1.3	2.1	7.4	9.0	18.6	74.0	0	0	.2
Intensive-selection	12.5	25.0	98.5	1.2	2.0	7.3	7.7	14.8	57.7	1.2	2.1	7.7	10.1	19.6	76.5	0	0	0
Check													15.4	31.7	126.1	1.4	2.4	8.3

[1]Board-foot volumes--International 1/4-inch rule to an 8 inch top i.b., in trees over 11 inch d.b.h. Cubic-foot volumes--to a 4 inch top i.b. in trees over 5 inch d.b.h. Basal area (square feet) in trees over 5 inch d.b.h.

[2]Includes the first (and only) cuts on the clear-cut and diameter-limit plots and combines the original and 10-year cuts on the selection plots.

A third inventory was made in 1959. It was then decided to make a second cutting in plots C and D and to hold to the cutting cycle goals from then on. At this time, and before marking, more detailed and specific management goals and objectives were set up. (Table 2 shows these additional guides as well as those established in the beginning to define the programs.) These involved: (1) defining a desired stand structure, setting the maximum-sized tree to leave, and proposing the eventual residual growing stock; (2) establishing a marking policy to indicate the amount and distribution of cut until management goals are attained; and (3) establishing a policy concerning favoring or discriminating against certain species.

Table 2.--Guides to cutting

Guides	Method of cutting			
	Clear-cut	Diameter-limit	Extensive-selection	Intensive-selection
Cutting cycle ..... years..	60-70	20	10	5
Maximum-sized trees to be left . inches..	None	15.5	32	32
Minimum-sized tree cut ..... inches..	5.1	15.6	11.1	5.1
Minimum-sized cull killed ..... inches..	None	15.6	11.1	5.1
Diameter ratio or "Q" ..... ratio..	None	None	1.3	1.3
Residual basal area in merchantable trees above 11 inches ..... square feet..	None	None	70	70

The following discussion of the detailed management guides applies only to plots C and D. The program definitions for the clear-cut and diameter-limit practices give no consideration to stand structure, residual stocking, nor species composition.

STAND STRUCTURE

The high growth potential of this site means that large trees of good species can be grown in a relatively short time. (Vigorous yellow-poplar will reach 14 to 20 inches d.b.h. in 50 years, and red oak will do about as well.) Because of this growth rate, product objectives are good-quality sawlogs and veneer logs. The stand structure guide selected for both plots C and D is a "Q" ratio[3] of

[3]The 'Q' ratio is Meyer's quotient (4) and refers to the ratio of trees by successive diameter classes. For example, if it is planned to retain one tree per acre in the largest size class, say 30 inches, then 1.3 trees will be retained in the 28-inch class, 1.69 trees in the 26-inch class, and so on. Determination of the number of trees to be retained in each class is based on the maximum-sized tree, the residual basal area, and the constant quotient or desired ratio--'Q'.

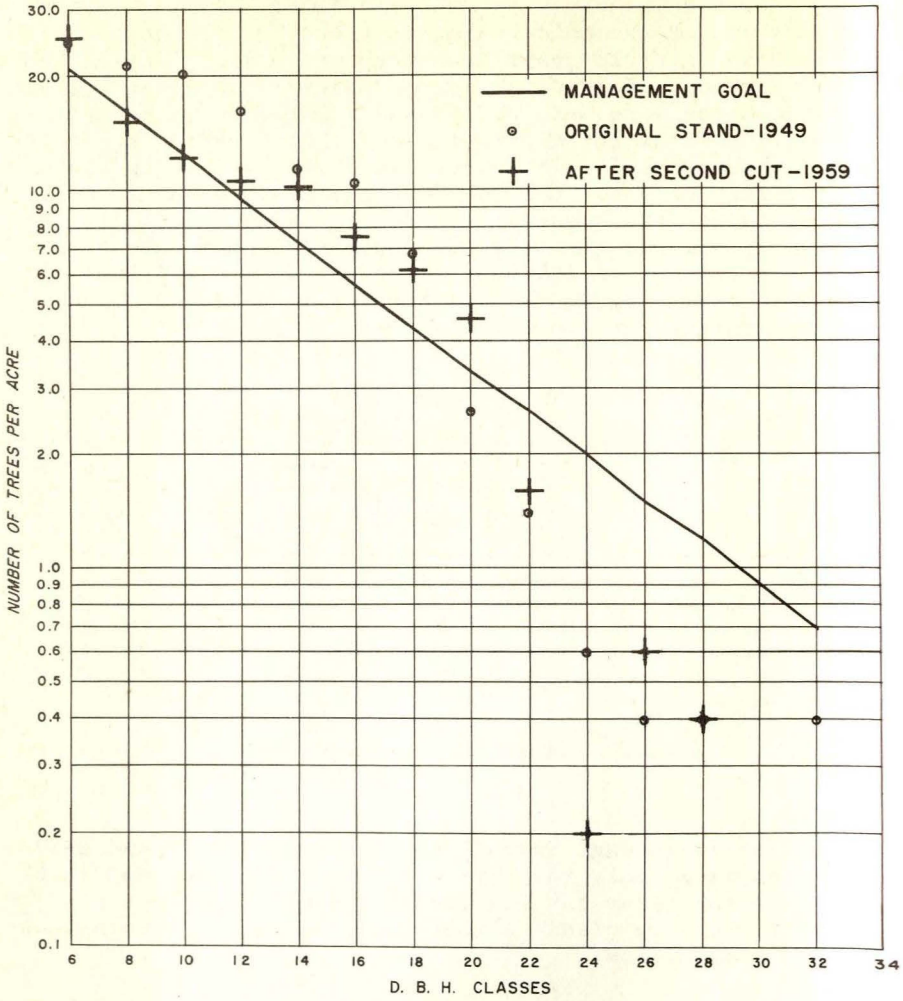


Figure 1.--*Number of trees per acre in different diameter classes, intensive-selection plot.*

1.3. With this ratio determining the distribution of diameter classes, a high proportion of the volume in the managed stand will be in the larger trees.

In both plots, 32 inches d.b.h. was set as the maximum size for trees to be left. This is a general guide, not an inflexible objective, and adherence to it will be tempered by judgment of such factors as tree vigor, tree grade, and species.

On the basis of experience on the Fernow Forest, and work done elsewhere, it was decided to set a goal of 70 square feet basal area in the sawtimber-sized portion of the stand as residual growing stock to be left after cutting.

For plot D, where cutting is done down to 5 inches d.b.h., this means a residual-basal-area goal of approximately 86 square feet in trees above 5 inches.

The number of trees to be retained in each d.b.h. class as residual growing stock is shown graphically in figure 1.

After management goals are attained, the residual stands will carry about 13,000 board feet per acre of sawtimber in trees above 11 inches d.b.h., or about 2,400 cubic feet in trees above 5 inches d.b.h.

DISTRIBUTION OF CUT DURING DEVELOPMENT PERIOD

During this period it is the marking practice to designate for cutting most of the excess trees in each diameter class; that is, those above the line in figure 1. An estimated 60 to 80 percent of the growth will be harvested during the interim period until the stands reach the desired stocking. Based on a possible range of growth from 400 to 550 board-feet per acre per year, the amount to be cut will probably range between 250 and 450 board-feet per acre per year.

PREFERRED SPECIES

It is recognized that changing markets and improving techniques in wood handling affect species preference. Still, certain species are desirable now and probably always will be. Others are not desirable because of low market value, poor growth, or poor log-grade characteristics. On good sites such as are represented by the plots, the forester generally has the opportunity to choose between a number of species. Marking to favor some or discriminate against others is practicable. On these plots, it was decided to discriminate against such species as black birch, beech, hickory, and ironwood. These comprised the bulk of the poor species found on these plots.

After the goals and guides outlined above were developed, the intensive- and extensive-selection plots were treated a second time. Two thousand board-feet per acre were removed from the former, and 1,900 board-feet per acre from the latter. Prescribed cull removal and grapevine cutting were carried out. On the intensive-selection plot, this second treatment also included pruning approximately five sugar maple stems per acre. These were pruned to heights of 13 to 17 feet.

RESPONSE TO DIFFERENT TREATMENTS

The effects of the management programs upon the stands are compared and described in terms of growth, changes in quality, reproduction, and stand structure.

GROWTH RATES

Based on the net growth rates for the 10-year period, the management programs can be rated in the following order: (1) intensive selection--524 board-feet; (2) diameter limit --446 board-feet; (3) extensive selection--424 board-feet, and (4) clear-cut--86 board-feet (table 3). These annual growth rates, based as they are on only a short measurement period, are far from conclusive as to the average annual growth to be expected under the different treatments.

Table 3.--Periodic annual net volume and basal-area growth per acre in merchantable trees

Plots	Ten-year growth		
	Cubic feet[1]	Board feet[2]	Basal area[3]
Clear-cut	53.6	85.7	2.6
Diameter-limit	86.1	445.7	3.4
Extensive-selection	85.1	423.9	3.3
Intensive-selection	93.8	524.3	3.6

[1]To a 4-inch top i.b. in trees over 5 inches d.b.h.

[2]International 1/4-inch rule to an 8-inch top i.b. in trees over 11 inches d.b.h.

[3]In trees over 5 inches d.b.h.

Growth rates have been consistent over the 10-year period for the areas of intensive and extensive management. As compared to the first 5-year average annual growth, the 10-year growth for the clear-cut and diameter-limit plots has increased remarkably. On Plot A, ingrowth forms all of the merchantable sawtimber increment in the 10-year period.

Special caution should be exercised in judging the early results of a diameter-limit cutting. The known disadvantages of this method of cutting often do not show up for some time (2). Some of these disadvantages are: (1) not cutting in the small size classes, which slows up growth rates of crop trees by maintaining a denser stand of young poles and small sawtimber than needed for the final crop; (2) in general, cutting trees of greater vigor first, leaving more slower-growing trees; (3) cutting trees of faster-growing species first; (4) and having no control over species composition and spacing. It is unlikely that the effects of this type of management will be fully expressed until at least two cuts have been made on this plot.

A factor that may account in part for the favorable growth rates of the diameter-limit cut is the fact that this plot contains more of its volume in fast-growing species such as yellow-poplar, black cherry, white ash, and red oak than the other plots. The contrast in growth rates is particularly sharp with the extensive plot, which contains a high volume of slow-growing hickory.

Figures 2, 3, 4, 5 and 6 show the plots in 1959 after plots C and D were cut.

QUALITY

Timber quality is a necessary consideration in hardwood management. The intensity with which it is profitable to practice silviculture in this hardwood region usually depends more on the possibilities of improving timber quality than on any other consideration. In judging the effects on timber quality of the four different programs, three facets of this problem are important: log quality, species composition, and cull material.

Log Quality

Log-grade surveys were made to determine the proportions of sawlog volume in the six log grades used on the Fernow Forest. The grades for factory-lumber logs as developed by the Forest Products Laboratory (1) are used as the first three categories. Grade 4 is a structural-timber log; grade 5 is a local-use log, too rough for lumber or structural timbers but sound and suitable for some mine timbers, pulpwood, or charcoal wood. Grade 6 is unmerchantable material in sound trees. This last grade is appreciably less than defect deducted in scaling for two reasons: it refers only to half logs (8 feet) or longer that are cull, and it does not include much of the unseen defect that shows up after the tree is felled and bucked.

Figure 2.--*Clear-cut Plot (A), 10 years after cutti*

Figure 3.--*Diameter-limit plot (B), 10 years af cutting.*

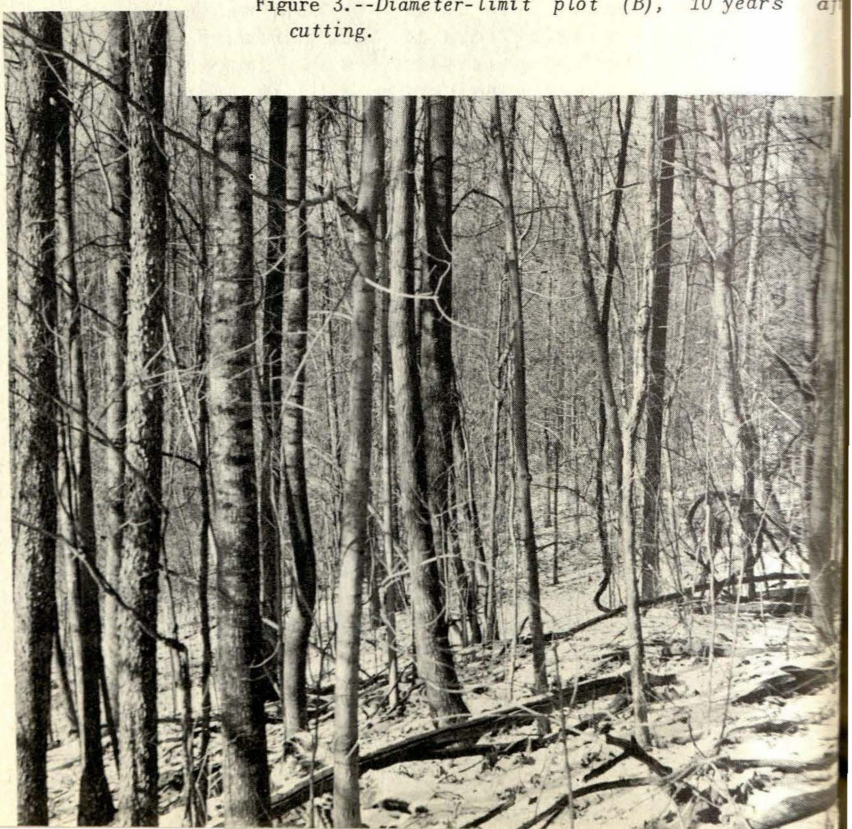


Figure 4.--*Extensive-selection plot (C), immediately after the second cut.*

Figure 5.--*Intensive-selection plot (D), immediately after the second cut.*

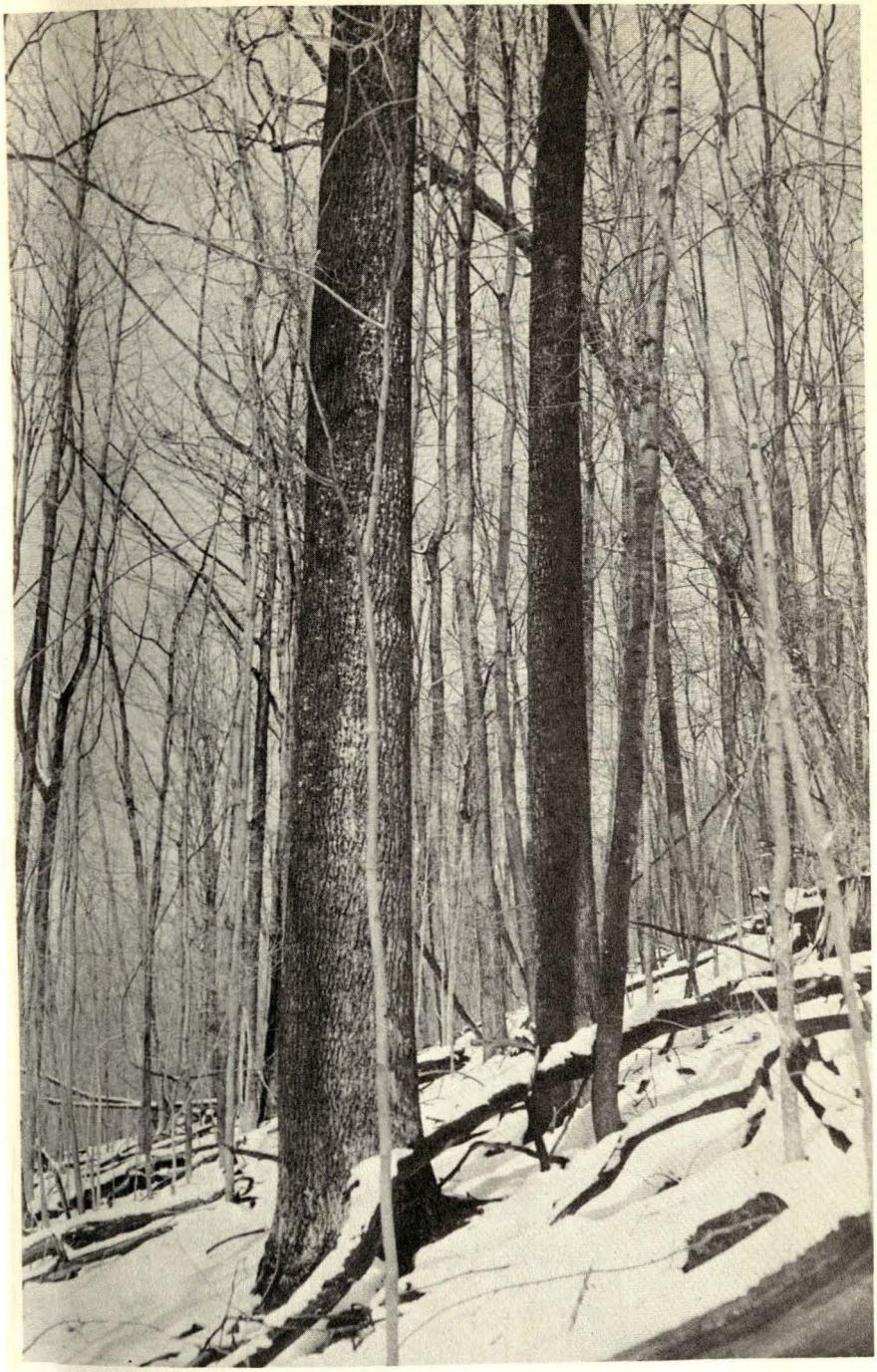


Figure 6.--*The check plot (E) in 1959.*

A comparison by stands of the original log-grade composition with the grade composition after 10 years (table 4) demonstrates the great improvement in the selectively-cut stands. The diameter-limit cut shows a moderate improvement, while the clear-cut now has no volume in log grades better than grade 4. The present condition of these stands is characterized by the proportions of sawlog volume in log grades 1 and 2. The intensively-managed stand now has 49 percent of its volume in these grades; the extensively-managed stand has 48 percent; the diameter-limit cut has 41 percent; the clear-cut has none (fig. 7).

On the uncut and unmanaged check stand only about 26 percent of the volume is in Log Grades 1 and 2 (table 4 and figure 7). Based on this fact, the possibility of quality increment through management on good sites is excellent. In the many high-graded stands throughout this region with an even lower portion of good grade logs than plot E, the possibilities of quality improvement through management are even greater.

It is doubtful if in the future the extensively-managed plot will produce quite as high-average quality logs as the intensively-managed plot. In the latter plot, the culling process begins with trees above 5 inches d.b.h., while no cutting takes place in the former below 11 inches.

Species Composition

No discussion of quality, particularly in relation to lumber grades, can be complete without reference to species. In this locality, at present, several species have no market as lumber, and they hardly pay their way out of the woods. For these trees, reduction of defect is about the only type of quality increment. Where there are many species to choose from, stand quality can be improved by marking practices that discriminate against the less desirable species. On good sites, because of the wide choice of species and because of abundant reproduction of good species (to be discussed later), it is possible to work toward a managed stand composed largely or entirely of desirable species in the sawtimber sizes.

To date, treatment in all stands has increased the percentage of total stems of desirable species (table 5). In all except the commercial clear-cut stands, the number of stems of desirable species has also increased.

On the selectively-cut plots, by the time management goals are reached, the stand on plot D above 11 inches should be composed largely of sugar maple and yellow-poplar with admixtures of some or all of the following: white ash, basswood, red maple, red oak, and black cherry. Most beech

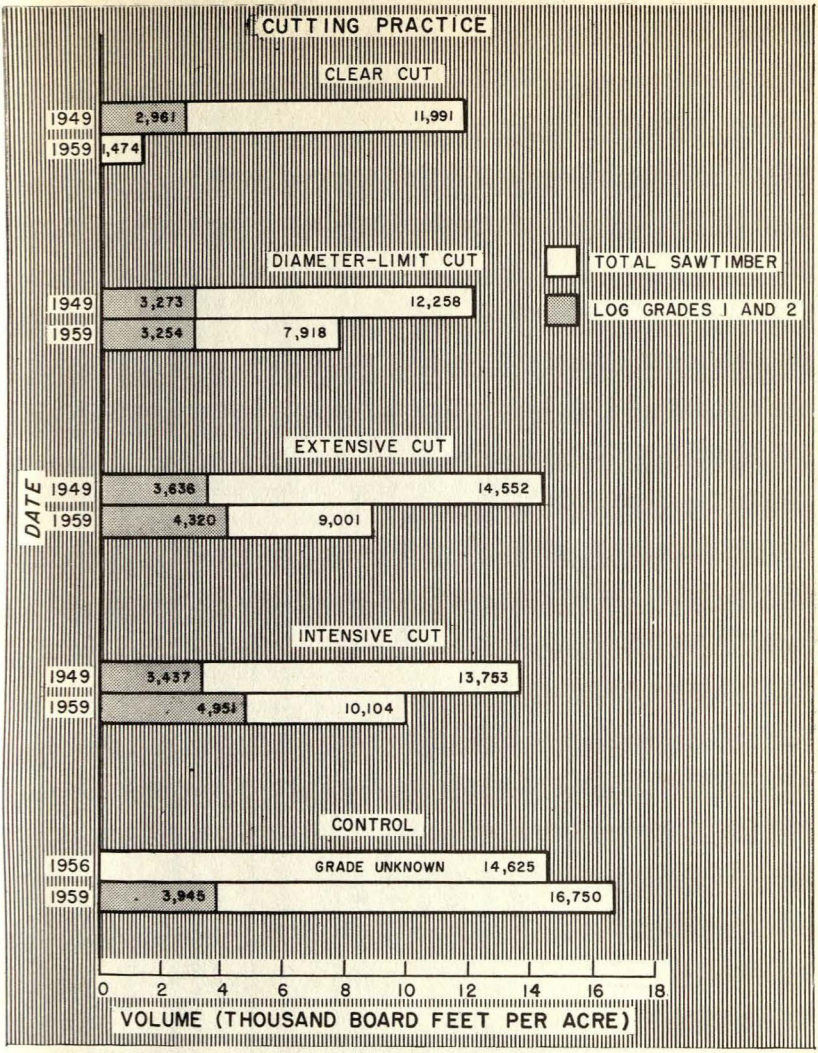


Figure 7.--*Total sawtimber volume and volume in log grades 1 and 2.*

and hickory will be eliminated before they reach sawlog size. On plot C, some of these now less-desirable species will reach small sawlog size since no cutting is done in the poletimber trees.

Cull Material

Cull trees and defect in merchantable trees (including rot and sweep) represent a tremendous loss in our forests. Before cutting, the Fernow compartments had run from

Table 4.--Stand quality as shown by percent of sawlog stand volume in different log grades and in cull trees

Quality	Original stand 1949[1]				Residual stand 1959				
	Clear-cut	Diameter-limit cut	Extensive-management	Intensive-management	Clear-cut	Diameter-limit cut	Extensive-management	Intensive-management	Check
Log grade									
1	6.0	6.5	6.1	6.1	0	26.8	28.4	31.6	12.3
2	18.7	20.2	18.9	18.9	0	14.3	19.6	17.4	11.3
3	35.0	37.9	35.5	35.5	0	44.8	39.0	37.8	36.4
4 and 5	25.7	27.8	26.0	26.0	58.1	12.0	11.6	11.8	30.0
6	4.7	5.1	4.7	4.7		1.9	1.4	1.4	1.7
Cull trees	9.9	2.5	8.8	8.8	41.9	0.2	0	0	8.3
Total sawtimber volume-M.b.f.	12.0	12.2	14.6	13.7	1.5	7.9	9.0	10.1	16.8

[1]The original grade survey of merchantable trees included plots A, B, C, and D in one sampling. Thus the grades shown here are the same for all plots except for the adjustment to account for a different volume in cull trees on the different plots. Stand quality for all 4 plots actually was quite uniform. The check plot was not established until later.

15 to 40 percent defective material. Reduction of the number of cull trees is one of management's highest priorities. In the original stands, defect in cull trees ranged from 2.5 percent of sawlog-stand volume in the diameter-limit plot to 9.9 percent in the clear-cut (table 4). Today, the percentages of sawlog volume in cull trees is: intensive and extensive management, none; diameter-limit cutting, 0.2 percent; and clear-cut, 41.9 percent.

Cull trees represent only part of the defect in the stand. In the original stand on the clear-cut plot, approximately 25 percent of the volume of the merchantable trees was defective. While comparable measured data are not available for the other plots, the stands were very similar, and it can be assumed that deducted defect in all plots on the first cut was somewhere between 10 and 30 percent. In comparison, on the second cut in the selection plots, deductions for defect were well below 5 percent. It is expected that in later cuts in these selectively-managed areas defect in sawlog trees will be even lower.

Table 5.--Ten-year change in species composition based on trees over 5 inches d.b.h.

Management program	Total number of stems per acre		Desirable species in percent of totals[1]		Change in number of stems of desirable species during the 10-year period
	Initial	After 10 years	Initial	After 10 years	
	No.	No.	Percent	Percent	No.
Commercial clear-cut	139	91	63	88	- 7
Diameter-limit	117	121	72	89	+23
Extensive-selection	102	102	45	66	+21
Intensive-selection	117	94	61	79	+ 3

[1]Desirable species are: black cherry, yellow-poplar, sugar maple, red maple, red oak, white oak, basswood, white ash, cucumbertree, and black walnut. Undesirable species are: beech, hickory, black birch, ironwood, black locust, aspen, butternut, dogwood, and Fraser magnolia.

Cull trees will be eliminated before reaching sawlog size in the intensively-managed plot and will never grow much above 11 inches d.b.h. in the extensively-managed plot. In the diameter-limit cut, culls will be deadened when they reach 15.6 inches d.b.h. Below this diameter they will continue to occupy growing space. In the commercial clear-cut, without removal, cull trees will remain in the stand until, after several harvests, they will probably make up much of

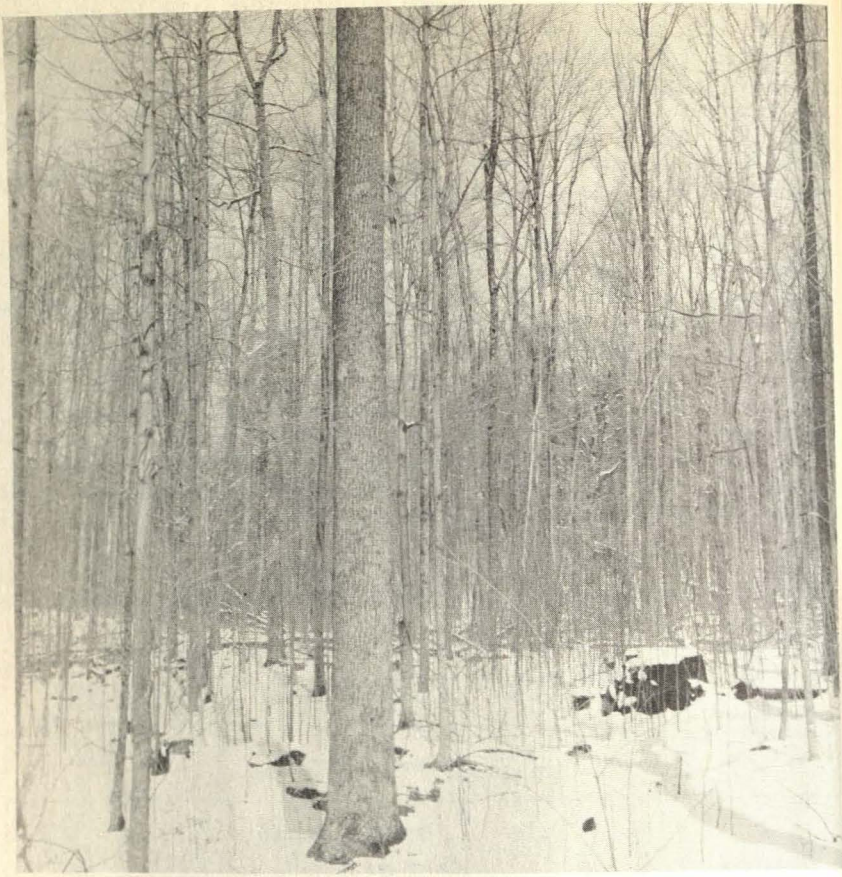


Figure 8.--*A high-grade yellow-poplar 22 inches in diameter in the intensively-managed plot. Fast-growing, good-quality trees like this are highly desirable growing stock.*

the stand volume. This is the typical trend in all high-grading operations where culls are not removed. The contrast between good trees and culls is shown in figures 8 and 9.

REPRODUCTION

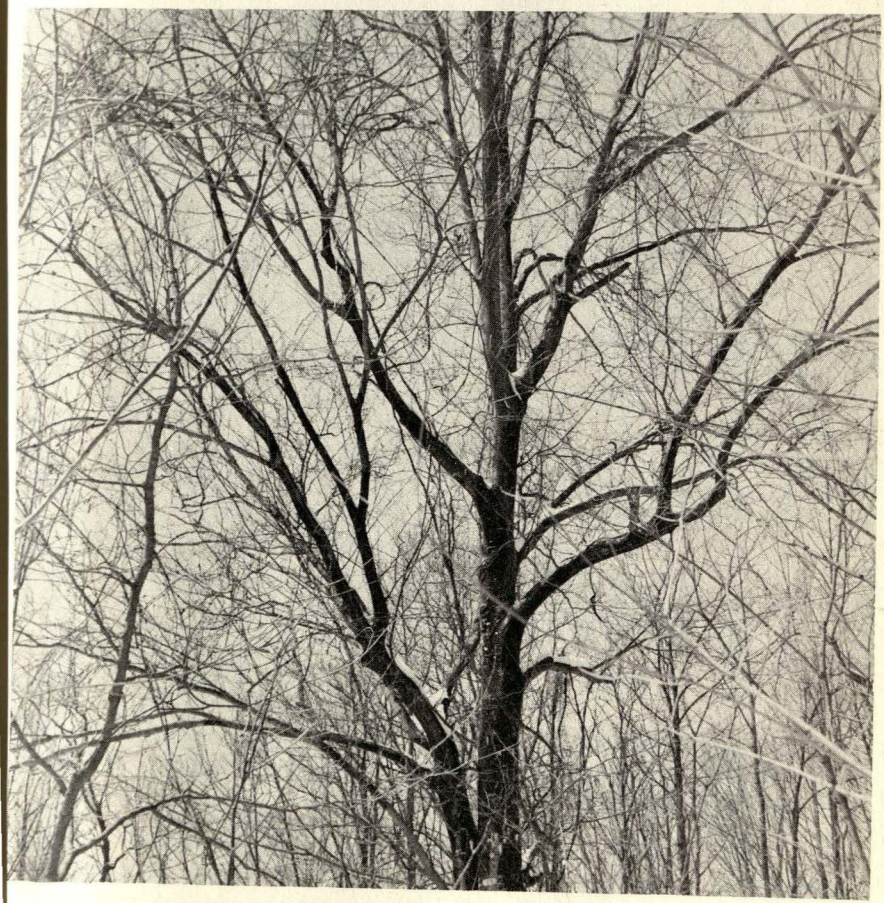
As mentioned previously satisfactory stand regeneration is a prerequisite to uniform harvests made at regular intervals.

What is satisfactory reproduction? And can we be assured of obtaining it on these sites under the management systems being applied? How does reproduction compare under the four methods of cutting?

Is Reproduction Satisfactory?

Satisfactory reproduction can be defined as an adequate quantity of well-distributed, good-quality stems of desirable species. As a guide to adequacy we can use the desired number of trees in the future stand in d.b.h. classes 6 to 10 inches (fig. 1). In these size classes, based on a "Q" of 1.3, we need a total of about 50 trees of fair-to-excellent quality. Broken down into 2-inch classes, we need 21 trees in the 6-inch class; 16 in the 8-inch class; and 13 in the 10-inch class. The present number of good saplings appears to be adequate for projected needs (table 6). In plot D there are 27 stems in the 4- to 5-inch class and 64 in the 3- to 4-inch class. This is more than the number needed to supply the 21 stems required in the 6-inch class.

Figure 9.--*This big-crowned cull beech in the clear-cut plot is taking up space that could be growing valuable timber.*



Is Reproduction Well Distributed?

The reproduction measurements were made on milacre plots on a grid system for the 1-foot-high to 1-inch-d.b.h. stems. A measure of the distribution of reproduction is the percent of plots stocked with commercial species. For all four cutting areas, this distribution is good (table 6).

Is the Quality of Reproduction Good?

In our measurements, reproduction quality was considered with reference to individual stem form and vigor, origin (whether seedling or sprout), and species. An abundance of reproduction of acceptable individual stems (commercial species of seedling origin) was found in all cutting plots (table 6). It is interesting to note that the clear-cut plot has the greatest percentage of sprouts, followed by the diameter-limit cutting--excluding plot E. The high per-

Table 6.--Number of stems per acre of commercial species, 10 years after the first cutting[1]

Treatment	1 foot high to 1 inch d.b.h.			1 to 5 inches d.b.h.	
	Number	Percent sprouts	Percent milacres stocked	Number	Percent sprouts
Clear-cut	5,878	23	92	764	36
Diameter-limit	5,875	21	88	495	24
Extensive-selection	9,688	13	100	500	11
Intensive-selection	8,333	10	98	331	9
Check	875	48	48	412	10

[1]All except check plot, which was never cut.

cent of sprouts in this check area is due mostly to the large number of beech root suckers and to a lesser extent to sprouts from weak and dying saplings.

The species composition of the seedlings was found to more nearly reflect effects of the management system than

Table 7.--Reproduction: Five leading commercial species (seedlings and sprouts) ranked in order by number of stems per acre, 1959.
(10 years after first cutting)[1]

Plots	One		Two		Three		Four		Five	
	Species	No.	Species	No.	Species	No.	Species	No.	Species	No.
					Seedlings[2]					
Clear-cut	S. maple	2,674	Y. poplar	1,102	Am. beech	531	Bl. cherry	429	White ash	367
Diameter-limit	S. maple	2,938	Y. poplar	1,271	Am. beech	438	Hickory	354	Bl. cherry	188
Extensive-selection	S. maple	4,208	White ash	1,583	Y. poplar	1,271	Bl. cherry	833	Am. beech	688
Intensive-selection	S. maple	3,354	Y. poplar	1,708	White ash	1,167	Hickory	708	Am. beech	563
Check	S. maple	437	Am. beech	333	Hickory	62	Basswood	21	White ash	21
					Saplings[3]					
Clear-cut	Bl. locust	227	S. maple	171	Y. poplar	114	Am. beech	35	White ash	35
Diameter-limit	S. maple	167	Bl. locust	108	Y. poplar	73	Basswood	46	Hickory	35
Extensive-Selection	S. maple	273	Am. beech	52	Bl. locust	44	Y. poplar	42	Hickory	25
Intensive-selection	S. maple	190	Am. beech	52	Y. poplar	44	Ironwood	12	Bl. birch	12
Check	S. maple	192	Am. beech	135	Basswood	25	Hickory	19	Red oak	10

[1]All except Check, which was not cut. [2]1 foot high to 1 inch d.b.h. [3]1 to 5 inches d.b.h.

the species composition of the saplings. Except on the clear-cut (and to some extent, the diameter-limit plot), where some sprouts that followed cutting have reached sapling size, a majority of the saplings were already present on the plots when they were first cut. There seem to be sufficient stems of the more valuable species of this reproduction in plots C and D (table 7) to permit bringing through to sawlog size a stand composed largely of these species.

On the basis of the 10-year measurements, it appears that to date the treatment programs used on all plots have permitted satisfactory reproduction (fig. 10). Only time will tell whether the selection-management system as currently practiced will maintain conditions suitable for continued growth of the more intolerant species among the reproduction. It may be necessary to deliberately create openings larger than normally occur where it appears desirable to favor the relatively intolerant types.

Table 8.--Number of trees by broad diameter (in inches) classes per acre

Item	Clear-cut			Diameter-limit			Extensive-selection			Intensive-selection		
	6-10	12-22	24+	6-10	12-22	24+	6-10	12-22	24+	6-10	12-22	24+
Original stand	102	32	4	74	39	4	54	45	3	66	49	2
After first cut	22	0	0	51	20	0	35	29	1	44	29	1
Before second cut	84	8	0	81	40	0	65	45	2	65	50	2
After second cut	No cut--same as above			No cut--same as above			64	37	1	52	41	1
Management goal	None			None			No set number	33	6	50	33	6

STAND STRUCTURE

The effects of the treatment upon stand structure are shown by the change in the distribution of trees by diameter classes (table 8). Obviously, clear-cutting of trees to between 5 and 6 inches changed the stand on plot A from uneven-aged to essentially even-aged. The diameter-limit cutting greatly reduced the spread of diameters. After several such cuttings at 20-year intervals, a 3- to 4-storied stand may result.

Since formal stand-structure guides are established for the selection plots, it is interesting to compare the number of trees by diameter classes in the original stand, the present stand, and the ideal stand under management (fig. 1). Inspection of these data (table 8) shows that for diameter classes up to the 22-inch class, there are at least as many trees as needed under the proposed "Q" ratio of 1.3.

Figure 10.--*In the foreground is a clump of 10-year old yellow-poplar seedlings that came in after the first cutting on plot D. These are 10 to 20 feet tall.*

From 24 to 32 inches (the maximum-sized tree) there is a deficit of stems. Based on an approximation of growth rates, it is estimated that at least 30 years will elapse before stand structure goals are attained.

SUMMARY

Ten years ago the first cuts were made under each of four different management programs on 5-acre plots located in Appalachian hardwood stands on good sites. The four management programs, or treatments, are: commercial clear-cut, 16-inch diameter cut, extensive-selection management, and intensive-selection management. Under the extensive-selection program, marking and cultural measures were confined to the sawlog stand; under intensive selection, cutting and cultural measures were carried out through the range of diameters above 5 inches d.b.h.

Ten years after the first cut, second cuts were made in the selectively-managed plots. Before marking for these second cuts, detailed silvicultural goals were set up as guides to management.

The report describes the effect to date of the four treatments on stand volumes, growth rates, timber quality, reproduction, and structure.

Average annual growth rates for the 10-year period in board-feet were: clear-cut, 86; diameter-limit, 446; extensive management, 424; and intensive management, 524.

In the original stands total cull volume in sawtimber was high, averaging perhaps over 25 percent. After 10 years cull material was greatly reduced in the selectively-cut and diameter-limit plots; in the commercial clear-cut area, it amounted to at least 42 percent of the residual sawtimber volume. The original stands contained only about 25 percent of the sawtimber volume in log grades 1 and 2. Today the percentages of log grades 1 and 2 in the stands are as follows: clear-cut, none; diameter-limit cut, 40 percent; extensive-management, 48 percent; intensive-management, 49 percent.

Reproduction of commercial species is abundant and well distributed on all plots.

Cutting has changed the clear-cut stand from uneven-aged to even-aged and has greatly reduced the spread of diameters in the diameter-limit cutting. In the selectively-cut stands with a structure goal of a "Q" ratio of 1.3 and a maximum-sized tree of 32 inches, there is a deficit of stems over 22 inches. It is estimated that at least 30 years will elapse before stand-structure goals are attained.

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